INSTRUCTION MANUAL

Type 1531-AB

STROBOTAC®

electronic stroboscope

GENERAL RADIO COMPANY

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electronic stroboscope

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GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

SPECIFICATIONS

Flashing-Rate Range: 110 to 25,000 flashes per minute in three direct-reading ranges: 110 to 690, 670 to 4170, and 4000 to 25,000. Speeds up to 250,000 rpm can be measured.

Accuracy: ±1% of dial reading after calibration on middle range.

Calibration: Two panel adjustments permit calibration against power-line frequency.

Flash Duration: Approximately 0.8, 1.2, and 3 μs for high-, medium-, and low-speed ranges, respectively, measured at ⅓ peak intensity.

Peak Light Intensity: Typical on high-, medium-, and low-speed ranges, respectively, 0.6, 3.5, and 11 million beam candles (6×10^5, 3.5×10^6, and 11×10^6 lux at 1 meter distance at the center of the beam); for single flash, 18 million beam candles (18×10^6 lux at 1 meter distance at the center of the beam).

Reflector Beam Angle: 10° at half-intensity points.

Output Trigger: 600- to 800-V negative pulse available at panel jack.

External Triggering: The flash can be triggered by the opening of a mechanical contactor or by a 6-V, peak-to-peak, signal (2-V, rms, sine-wave signal down to 5 c/s).

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 c/s. Maximum power input is 35 W.

Accessories Supplied: Adjustable neck strap, plug to fit input and output jacks, spare fuses.

Accessories Available: TYPE 1531-P2 Flash Delay and TYPE 1536-A Photoelectric Pickoff, TYPE 1539-A Stroboslave with TYPE 1531-P4 Trigger Cable, and TYPE 1532-D Strobolume with TYPE 1532-P3 Trigger Cable.

Mechanical Data: Flip-Tilt Case

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
10⅝†	270	6⅝	170	6⅛	160	7¼	3.3	9	4.1

† Includes handle.

See also *General Radio Experimenter*, September 1960.

U.S. Patent No. 2,966,257.

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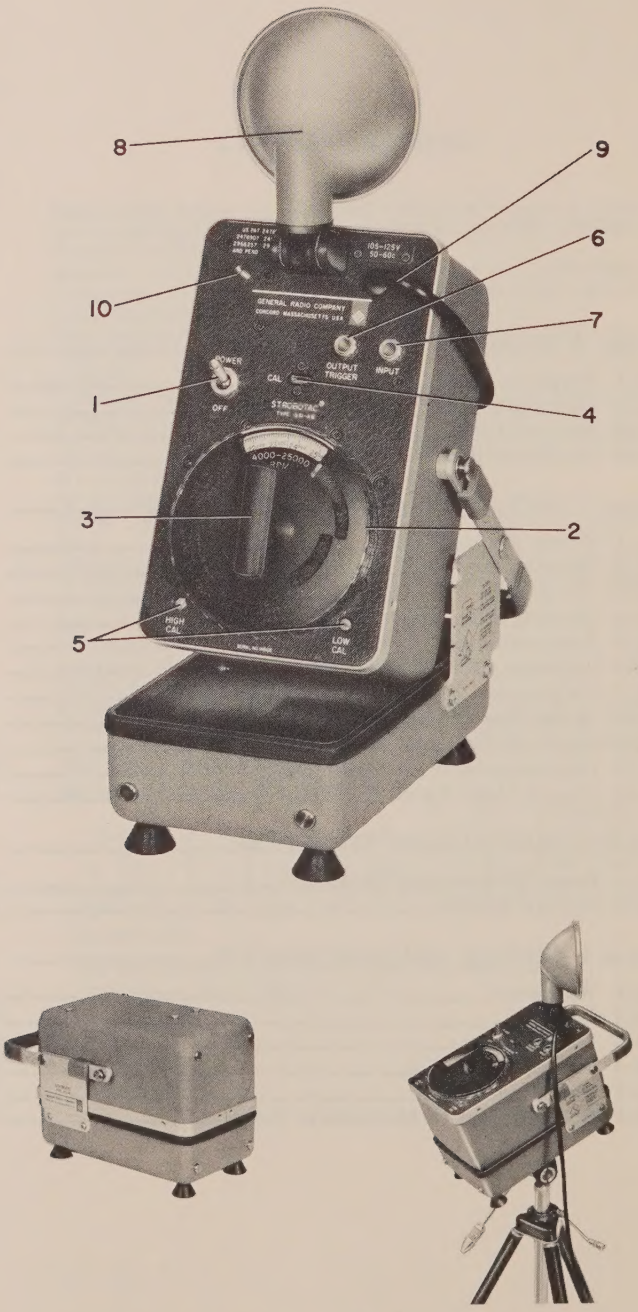


Figure 1-1. Type 1531 Strobotac® Electronic Stroboscope showing controls and connectors.

SECTION 1

INTRODUCTION

1.1 PURPOSE.

The Type 1531 Strobotac is a versatile flashing-light source that is used to measure the speed of fast-moving objects or to produce the optical effect of stopping or slowing down high-speed motion for purposes of observation, analysis, or high-speed photography.

1.2 DESCRIPTION.

1.2.1 GENERAL.

The Type 1531 is a portable electronic stroboscope that emits a high-intensity, short-duration, flash of light. The instrument includes a strobotron lamp and reflector, an electronic pulse generator that controls the flashing rate, and a line-operated power supply. A built-in calibration system utilizes the power-line frequency for checking and adjusting the flashing-rate calibration.

The strobotron lamp and reflector assembly is mounted on a swivel arm which can be pivoted 180°; the reflector can be turned 360°. Thus, the operator can conveniently aim the light beam in almost any direction while the instrument is hand-held or mounted in a stationary position. The high-intensity light will adequately illuminate most moving objects — even in relatively high ambient light — and it permits observation of distant and difficult-to-illuminate objects, in otherwise inaccessible areas.

The Type 1531 Strobotac is housed in the General Radio Flip-Tilt case, which protects the instrument when it is not in use and also serves as a convenient support for the instrument during operation (see Figure 1-1). When in use, the instrument can be held in the operator's hands, placed on any convenient flat surface, mounted on a conventional tripod, or supported by the neck strap provided.

1.2.2. CONTROLS AND CONNECTORS.

All controls and connectors are conveniently located on the panel of the instrument. See Figure 1-1 for location of controls and connectors referred to in Table 1-1.

Table 1-1

CONTROLS AND CONNECTORS
(see Figure 1-1)

Ref	*Name*	*Use*
1	POWER Switch	Turns power on and off.
2	RPM Control	Controls flashing rate of light by rotating fluted rim. Dial is calibrated directly in revolutions per minute.
3	Range Switch	Selects any of three RPM (internal oscillator) ranges, plus three external-input positions: RPM Ranges — External Input 110-690 RPM — High Intensity — 700 RPM max 670-4170 RPM — Med Intensity — 4000 RPM max* 4000-25,000 — Low Intensity — 25,000 RPM max
4	CALibration Indicator Lamp	Indicates correct setting of CALibration adjustments (Ref. 5) for calibrating RPM dial to power-line frequency.
5	HIGH CAL, LOW CAL	Calibration adjustments used for calibrating RPM dial.
6	OUTPUT TRIGGER Jack	Trigger pulse available at this jack for triggering Strobotac Types 1531 and 1538, Type 1539 Stroboslave, or Type 1532 Strobolume. (Refer to paragraph 2.9 and 2.10 for connection cables required.)
7	INPUT Jack	Used for connecting Stroboscope to external synchronizing signal from electrical device or mechanical contactor.
8	Reflector-Lamp Assembly	Produces and aims flashing light.
9	Power Cord	Permanently attached six-foot power cord. For storage, cord is wound clockwise around range-switch knob and reflector; plug is secured by sliding it onto holder pin (Ref 10).
10	Holder Pin	Secures plug-end of power cord when instrument is to be stored in case.

*Flashes at 3600 rpm until external signal is plugged in.

1.3 ACCESSORIES.

Table 1-2 lists the accessories supplied with the Type 1531 Strobotac.

Table 1-2

ACCESSORIES SUPPLIED

Part Number	*Description*	*Quantity*
1531-7070	Neck Strap	1
4270-1100	Plug, for input and output jacks	1
5330-1000*	Fuse, 0.5A, for 115-V operation	2
5330-0700*	Fuse, 0.25A, for 230-V operation	2

*Fuses supplied for voltage specified.

1.4 AUXILIARY EQUIPMENT.

Table 1-3 lists General Radio accessory equipment and auxiliary light sources available for use with the Type 1531 Strobotac.

Table 1-3

AVAILABLE ACCESSORY EQUIPMENT AND LIGHT SOURCES

Type	*Description*
	ACCESSORIES
1531-P2	Flash Delay (used with Type 1536 Photoelectric Pickoff.
1536	Photoelectric Pickoff (used with Type 1531-P2 Flash Delay).
1531-P3	Surface Speed Wheel.
	LIGHT SOURCES
1531	Strobotac Electronic Stroboscope
1538	Strobotac Electronic Stroboscope
1539	Stroboslave
1532	Strobolume

Refer to Section 2 (OPERATING PROCEDURE) and APPENDIX for details describing the use of this equipment with the Type 1531 Strobotac.

SECTION 2

OPERATING PROCEDURE

2.1 POWER REQUIREMENTS.

The Type 1531 Strobotac operates from a line frequency of 50 to 400 cycles, and from either a 105- to 125-volt, 195- to 235-volt, or 210- to 250-volt line input as noted on the plate located just above the power cord. The instrument is normally supplied for either 105- to 125-volt or 195- to 235-volt operation, but can be modified for 210- to 250-volt operation (refer to paragraph 4.4.3 and Figure 4-7).

2.2 OPENING THE CASE.

To open the case for operation:

a. Set the instrument on a flat surface so that it is resting on its rubber feet.

b. Unlock the case by sliding the two slide pins (one on each side) away from the handle. (It may be necessary to push down on the top of the instrument to release these pins.)

c. Using the palm of the hand, push the handle down as far as possible. With the other hand, swing the instrument to the desired angle. Lower the instrument onto the rubber gasket by slowly releasing the handle. The instrument will be held in position by its friction against the gasket at any angle from vertical to about 30°. However, since the case is not locked in position, it may not stay in a tilted position under severe vibration. If the instrument is to be hand-held, lower the case into the cover and lock it in position by sliding the locking buttons toward the handle.

2.3 CLOSING THE CASE.

Before closing the instrument, push the reflector down against the panel with the transparent reflector cover facing up. Turn the range-

switch bar knob to the 4000 – 25,000 RPM position and wrap the power cord clockwise around the knob and reflector. Secure the power-cord plug by sliding the ground terminal of the plug onto the holder pin (10, Figure 1-1). Lift the instrument until it is free to pivot on the handle and lower it into the case.

2.4 TURNING INSTRUMENT ON.

The following precautions should be observed before turning the stroboscope on:

a. Before plugging the power connector into a power receptacle, make certain the power corresponds to the data on the plate above the power cord on the panel.

b. The power plug has three terminals. For operator safety, the third pin on the power plug must be properly grounded.

Pivot the reflector assembly to an upright position and snap the power switch on. The stroboscope will be ready for use in about 10 seconds.

2.5 POSITIONING THE STROBOSCOPE.

The light beam can be aimed in almost any direction by means of the swivel arm and the rotating reflector. The intensity of the light pulse is so high that it is usually not necessary to place the unit very close to the object being viewed. If the instrument is to be held for a long time the neck strap can be used to provide added support. The neck strap can be adjusted to any one of three lengths. To install the strap, slip the appropriate slots in the strap over the buttons projecting from the side of the case.

2.6 ADJUSTING THE FLASHING RATE.

The flashing rate of the strobotron lamp is adjusted by means of the RPM control. To operate this control, grasp the fluted transparent rim which surrounds the range mask. The over-all frequency range of the Stroboscope is divided into three overlapping ranges, selected by the range-switch bar knob. Windows on the range mask reveal only the range in use. A red line inscribed below the RPM dial indicates the frequency setting in flashes per minute (corresponding to rpm) for speed measurements. The frequency limits for each range are marked near the appropriate window. The range switch has no limit stops and can therefore be rotated continuously. The rotation of the RPM control, however, is limited to 300 degrees by stops.

2.7 CALIBRATION.

2.7.1 GENERAL.

If the instrument is to be used for speed measurements, the RPM dial should be calibrated with respect to the power-line frequency. The Type 1531 Strobotac will normally remain calibrated for a considerable period of time, unless significant changes occur in ambient temperature or in the power-line voltage.

To calibrate the stroboscope, proceed as follows:

a. Allow the instrument to warm up for about 10 minutes.

b. Refer to the calibration table in the instrument cover or to Table 2-1 for the HIGH CAL and LOW CAL RPM dial settings indicated for the power-line frequency being used. Turn the range switch to the corresponding range required to make these settings.

c. Set the RPM dial to the exact HIGH CAL RPM dial setting called for in the calibration table.

d. Adjust the HIGH CAL screwdriver control until the on-off pattern of the CAL neon indicator lamp stops, or nearly stops (refer to paragraph 2.7.2).

e. Set the RPM dial at the exact LOW CAL RPM dial setting indicated in the calibration table and adjust the LOW CAL screwdriver control until the on-off pattern of the CAL neon indicator lamp stops, or nearly stops.

f. Return the RPM dial to the HIGH CAL RPM setting. If the CAL indicator lamp blinks on and off too rapidly, repeat steps d, e, and f. This step is usually not necessary unless the LOW CAL adjustment was changed substantially.

g. The RPM dial is now calibrated to within 1% on all scales.

Table 2-1

CALIBRATION DATA

Power-Line Frequency	*RPM Dial Settings* HIGH CAL	LOW CAL
50	3000	750
60	3600	900
400	24,000	6000

2.7.2 CALIBRATION ERROR.

The action of the CAL indicator lamp is used to determine when either of the HIGH CAL or LOW CAL adjustments are properly set. Extremely slow on-off action of the lamp indicates the calibration setting is very close to the line frequency and generally accurate enough for most speed measurements. If desired, the calibration error can be calculated as follows:

a. First, observe the period (in seconds) required for the CAL indicator lamp to complete one full cycle – on to off to on again, for example.

Then, calculate the calibration error by:

$$\frac{\text{RPM}}{\text{line frequency (c/s)} \times T} = \text{rpm error}$$

where T = time (in seconds) for one cycle of CAL indicator lamp

Example - if the CAL lamp period equals 2 seconds, the line frequency is 60 c/s, and the RPM dial is set at 900; the calibration error is:

$$\frac{900}{60 \times 2} = 7.5 \text{ rpm}$$

2.8 SPEED MEASUREMENT.

2.8.1 FUNDAMENTAL SPEED.

When measuring the rotational speed of an object, it is recommended that the RPM dial be set initially at a higher flashing rate than the speed of the object. Then, slowly reduce the flashing rate until the first single image is observed. At this point, the flashing rate of the stroboscope will be equal to the rotational speed of the object, and the speed can be read directly from the RPM dial.

When using the middle- or low-speed ranges, simply switch to the next higher range without moving the RPM dial setting to check whether the stroboscope is flashing at the fundamental speed of the object. Since the ratio between ranges is exactly 6:1, six images will appear at the next higher range, if the stroboscope has been set to the fundamental speed. If only three images appear, for example, then the stroboscope has been set to one-half the correct frequency. On the high-speed range, it is necessary to double the speed setting to check for fundamental-speed operation. A double image should occur when the frequency setting is doubled. If the fundamental speed of the device being measured is above 12,500 rpm, it is not possible to check for correct speed setting by the method outlined above. In this case, refer to paragraph 2.8.3.

With practice, and especially when the approximate speed of the object can be estimated, an operator can accurately measure the speed of rotating objects quickly, and with confidence. It is necessary, however, to thoroughly understand the following basic principles involved in making speed measurements with a stroboscope:

- The operator must distinguish between single and multiple images. Odd shaped objects usually cause little difficulty, but objects which are symmetrical in shape (gear, disc, fan, etc) must be marked to provide a visible reference (refer to PRINCIPLES OF OPERATION, paragraph 3.1.2).
- Multiple images will *always* be observed when the stroboscope flashing rate is set to a multiple of the fundamental speed of the object.
- When reducing the flashing rate from a rate higher than the fundamental speed of the object, the *first* single image will be seen when the flashing rate is equal to the fundamental speed.
- When the flashing rate is below the fundamental speed of the object, single *and* multiple images will be observed. The single images will always occur at integral submultiples of the fundamental speed of the object (refer to paragraph 2.8.2).

2.8.2 SUBMULTIPLE SPEED MEASUREMENTS.

If the Type 1531 Strobotac is set to flash at an integral submultiple of the fundamental speed of a rotating object, a single image will be observed, just as it will at the fundamental speed. At flashing rates between these submultiples, multiple images will be observed. Table 2-2, for example, shows the number of images that will be obtained at various stroboscope flashing rates (below the fundamental speed) of a device rotating at exactly 1800 rpm.

Note the numerical relationship between the numerator of the submultiple fraction and the corresponding number of images seen. This relationship will always hold true, regardless of the speeds involved. Table 2-2 lists only a few of the more useful submultiple speeds and corresponding images; many other multiple images are possible (for example, five images will be seen at 5/7, 5/8, etc.).

Submultiple flashing is necessary to observe or measure the speed of objects moving at rates above 25,000 rpm. Refer to paragraph 2.8.3 for the method of determining the fundamental speed when submultiple operation is necessary.

Table 2-2

SUBMULTIPLE SPEED/IMAGE RELATIONSHIP

Submultiples of Fundamental Speed (1800 rpm)	*Number of Images Seen**	*RPM Dial Setting*
1	1	1800
5/6	5	1500
4/5	4	1440
3/4	3	1350
2/3	2	1200
3/5	3	1080
1/2	1	900
2/5	2	720
1/3	1	600
1/4	1	450
1/5	1	360
1/6	1	300

*At dial settings above fundamental speed, multiple images always occur. Refer to Table 4-1, paragraph 4.4.11.

2.8.3 MEASUREMENT OF SPEEDS ABOVE 25,000 RPM.

Speeds up to about 250,000 rpm can be accurately determined by calculations based on submultiple measurements. The procedure is as follows:

a. Starting at 25,000 rpm, decrease the flashing rate of the stroboscope until a *single* image is obtained. Record the RPM dial setting and call it X.

b. Continue to decrease the RPM dial setting slowly. Watch the changing images carefully, and stop when the *next* single image occurs. Record the RPM dial setting as Y.

c. Calculate the harmonic number, n, by:

$$n = \frac{Y}{X - Y}$$

and round off the value of n to the nearest whole number.

d. Calculate the fundamental speed, S_f, by:

$$S_f = nX$$

Example:

If X is 22,500 and Y is 16,800 , then:

$$n = \frac{16,800}{22,500 - 16,800} = 2.95 = 3$$

and the fundamental speed is:

$$S_f = 3 \times 22,500 = 67,500 \text{ rpm}$$

2.8.4 LOW-SPEED OPERATION.

The measurement of speeds (below 600 rpm) on the low range of the Type 1531 may be difficult because of flicker resulting from lack of persistence-of-vision. It is recommended that these measurements be made in a darkened environment, or that the operator wear dark glasses, in order to reduce the confusing effect of high ambient room lighting on the pattern observed.

Speeds below 110 rpm can be measured by means of multiple images. For example, if the flashing rate of the stroboscope is twice the fundamental speed of the device, two images, 180 degrees apart, will appear. At three times the fundamental speed, three images, 120 degrees apart, will appear. Refer to paragraph 3.1.2 for illustrations. This multiple-image technique can also be used for higher speeds, within the range of the Type 1531, where flicker makes it difficult to tell when the correct flashing rate is obtained (for example, between 110 and 600 rpm).

2.8.5 SLOW-MOTION STUDIES.

High-speed motion can be reproduced by the stroboscope at an apparently much lower speed if the rotating or reciprocating motion occurs at a constant rate.

If the flashing rate of the instrument is set at a speed slightly lower than the fundamental speed of the observed object, the object will appear to move slowly in the same direction as the actual motion, at a speed

equal to the difference between the actual speed of the object and the flashing rate of the stroboscope.

If the flashing rate is set slightly higher than the speed of the object being observed, the same slow motion will result, but in the opposite direction.

This stroboscopic technique of slowing down motion can be extremely useful in investigating the operation of a device under normal operating conditions. Excessive vibration, misalignment of parts, mode of vibration of equipment on a shake table, operation of vibrating reeds, actual relation between traveler and thread during a complete revolution of the traveler on a textile spinning frame-these are only a few examples of slow-motion studies that are possible with the Type 1531.

2.9 EXTERNAL SYNCHRONIZATION.

2.9.1 SYNCHRONIZING TO POWER-LINE FREQUENCY.

When using a 50- or 60-cycle power line, synchronization of the flashing rate is obtained automatically by setting the range switch to the LINE/EXT INPUT position. For 400-cycle operation, set the range switch to the EXT INPUT, LOW INTENSITY position and inject a 400-cycle signal at the INPUT jack (refer to paragraph 2.9.5).

2.9.2 USE WITH FLASH DELAY AND PICKOFF.

Two very useful accessories for the stroboscope are the Type 1531-P2 Flash Delay and the Type 1536 Photoelectric Pickoff. The combination of these three instruments makes it possible to synchronize the flash of the Type 1531 with the moving object at any desired point in the cycle of operation of the object. These synchronizing devices can operate at very high speeds and do not load the machine under observation. See Figure 2-1.

The Type 1531-P2 Flash Delay is a small, portable, time-delay unit that is used to insert a controlled delay period between an externally generated trigger pulse and the resulting light flash from the stroboscope. The flash delay also provides a convenient method of obtaining single-flash photographs at any desired point in the cycle of the moving object.

The Type 1536 Photoelectric Pickoff is used to convert the motion of a moving object to electrical impulses that can be applied to the stroboscope. It consists of a light source, a simple cylindrical optical system, and a photocell. Variations in reflectivity, produced by the motion of the object being observed, produce electrical signals which are amplified, delayed, and shaped by the Flash Delay, and then fed to the stroboscope. Power for both the photocell and the lamp are supplied by the Type 1531-P2 Flash Delay.

The reader should refer to the Operating Instructions for the Type 1531-P2 Flash Delay and the Type 1536 Photoelectric Pickoff for further information concerning these instruments and their use with the Type 1531 Stroboscope.

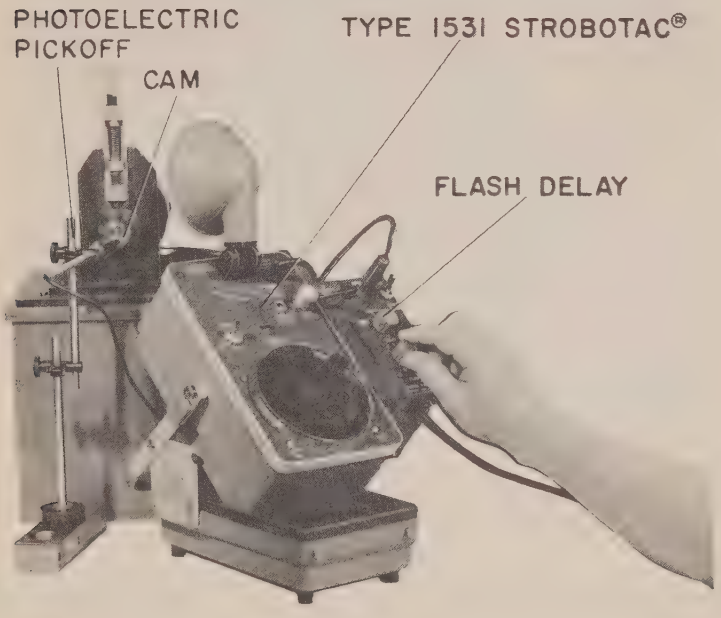


Figure 2-1. Synchronization of Type 1531 Strobotac with rotating cam, using Type 1531-P2 Flash Delay and Type 1536 Photoelectric Pickoff.

2.9.3 USE WITH LINEAR SPEED WHEEL.

The Type 1531-P3 Linear Speed Wheel is used with the Type 1531 for accurate measurement of linear speeds of moving objects, such as belts. This combination can also be used to determine the surface speeds of rotating devices, such as wheels, drums, rollers, etc., as well as the relative speeds of multiple V-belts and other groups of moving objects. See Figure 2-2.

The Linear Speed Wheel consists of two black nylon wheels of different diameters, freely turning on opposite ends of a steel rod. The three six-inch rod sections supplied have threaded ends so that one, two, or three lengths can be used. A 1/16-inch white radial strip and the proper speed-ratio data are marked on the surface of each wheel.

In use, the selected wheel is pressed against the moving object whose linear or surface speed is to be measured, and the rotating wheel is illuminated by the flashing light of the stroboscope. The dial of the

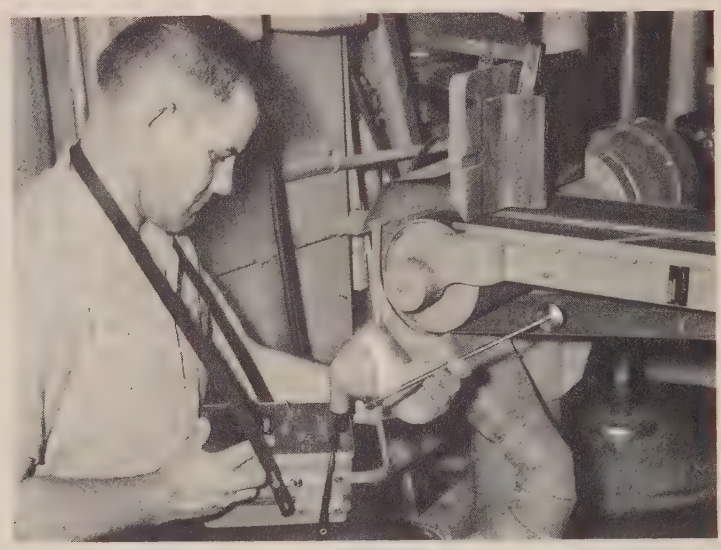


Figure 2-2. Measuring belt speed on a sanding machine, using Type 1531 Strobotac and Type 1531-P3 Linear Speed Wheel.

stroboscope is then adjusted to produce the proper stationary image. The linear speed of the moving object is determined from the stroboscope dial reading.

The range of surface speeds that can be measured with the large wheel is 50 to 12,500 FPM (feet per minute); with the small wheel the range is 10 to 2500 FPM. Press the appropriate wheel against the moving surface just firmly enough to prevent any slipping.

The large wheel is suitable for the measurement of relatively high linear speeds. It has a circumference of 0.5 foot and is marked "SINGLE IMAGE, FPM = RPM ÷ 2". Adjust the stroboscope dial to the highest setting that produces a single stationary image. (NOTE: To check the dial setting, switch the stroboscope to the next higher range. If the original setting was correct, six images will now be produced.) The linear speed of the moving surface in feet per minute is the stroboscope dial reading divided by 2.

The small wheel, suitable for the measurement of relatively slow linear speeds, has a circumference of 0.2 foot and is marked "2 IMAGES, RPM ÷ 10". Adjust the stroboscope dial so that a double stationary image is obtained. The image will appear as a full-diameter line on the wheel. (NOTE: To check the dial setting, turn the stroboscope dial to half of its double-image value. If the original setting was correct, a single image will now be produced.) The linear speed of the moving surface in feet per minute is the stroboscope dial reading divided by 10.

2.9.4 USE WITH A CONTACTOR.

For low-speed application (below 1000 rpm), where significant speed variations are encountered, it may be desirable to use a mechanical contactor, such as the General Radio Type 1535, for synchronization and phasing. The phase adjustment of this contactor is independent of the speed of rotation. The Type 1531 stroboscope will flash on the opening of the mechanical contact (refer to paragraph 3.2.7).

NOTE

Before connecting the contactor to the stroboscope, make sure the range switch is not in any one of the EXT INPUT positions. This precaution will prevent holdover of the thyratron when the plug is inserted. After the plug is connected, the range switch can be set to any desired position. If the stroboscope fails to flash because of holdover, turn the instrument off, and then on again after 10 seconds (refer to paragraph 3.2.2).

After making sure the range switch is not in an EXT INPUT position, connect the contactor to the INPUT jack, using the standard phone plug supplied. Then the synchronization procedure is as follows:

a. Set the range switch to one of the EXT INPUT positions, depending on the speed of the object being observed. The maximum speeds indicated can be exceeded up to the point where the lamp flashes erratically. Generally, the highest intensity position that allows satisfactory flashing of the instrument should be used.

b. Set the RPM control fully clockwise. If this control is not fully clockwise, the flash will occur at a delayed time after the contacts close and the unit will not operate properly at high speeds.

c. At speeds above 1000 rpm, some difficulty may result from multiple flashes when the Type 1535 Contactor is used to synchronize the stroboscope.

2.9.5 USE OF ELECTRICAL-SIGNAL TRIGGERS.

The instrument can be triggered by any electrical signal of at least 6 volts peak-to-peak amplitude (maximum of 500 volts). For sine-wave inputs, the unit will operate with a 2-volt rms signal down to 5 c/s.

For pulse inputs (i.e., step-wavefront signals), the repetition rate has no minimum value. The instrument can be synchronized with external signals of frequencies up to at least 24,000 rpm, 400 c/s. (Refer to paragraph 3.2.7.) Since a positive-going signal is required at the input to flash the stroboscope, positive pulses are required to synchronize on the leading edge. Negative pulses will result in a delay, depending on the trailing-edge characteristics of the input pulse.

To operate the unit from an external electrical signal, turn the range switch to one of the EXT INPUT positions, depending on the frequency of the driving signal. Connect the external-signal source to the INPUT jack. Observe the precaution given in NOTE, paragraph 2.9.4.

In the LINE/EXT INPUT position, the power-line excitation is automatically removed when a plug is inserted in the INPUT jack. In the EXT INPUT positions, the RPM control adjusts the sensitivity of the input circuit. Starting at the fully clockwise position, adjust the RPM control until satisfactory synchronization is obtained. For large-amplitude inputs, there will be a wide range of settings for the RPM control, at which the instrument will operate satisfactorily. For small-amplitude inputs, the range will be correspondingly smaller.

2.10 OPERATION WITH AUXILIARY LIGHT SOURCE.

2.10.1 USE WITH TYPE 1532 STROBOLUME.

When a wider beam of light, or substantially greater light intensity is needed, a Type 1532 Strobolume can be driven by a Type 1531 Strobotac. A Type 1532-P3 Trigger Cable is required to connect the two instruments.

Plug the large end of the cable into the OUTPUT TRIGGER jack on the panel of the stroboscope, and plug the other end of the cable in the CONTACTOR jack on the Strobolume.

NOTE

The Type 1532-P2B Transformer Cable, used with the older Type 631-BL stroboscope, cannot be used with the Type 1531.

A Type 1531 Strobotac can also be used to drive the older Type 1532-B, or -C Strobolume, but a modified Type 1532-P3 Trigger Cable is required to connect the two instruments. To modify the cable, simply replace the phone plug (small end) with the twist-lock plug required for the older type Strobolume.

2.10.2 USE WITH TYPE 1539 STROBOSLAVE.

The Type 1539 Stroboslave is used with the stroboscope when a second light source is needed, or when a difficult-to-illuminate object requires the use of a compact light source, mounted at the end of a flexible cord (see Figure 2-3). Since the Stroboslave has no internal oscillator, the trigger signal is supplied by the Type 1531 stroboscope through a Type 1531-P4 Trigger Cable. Plug the large end of this cable into the OUTPUT TRIGGER jack on the panel of the stroboscope, and plug the other end into the INPUT jack on the panel of the Type 1539 Stroboslave.

2.10.3 MULTIPLE STROBOSCOPE USES.

A second Type 1531, or a Type 1538 stroboscope, can be used in conjunction with the Type 1531 when a second source of flashing light is needed. A Type 1531-P4 Trigger Cable is required to connect the two instruments. Plug the large end of the cable into the OUTPUT TRIGGER jack of the "master" Type 1531. Then, plug the small end into the INPUT jack of the "slave" stroboscope; either a Type 1531 or a Type 1538.

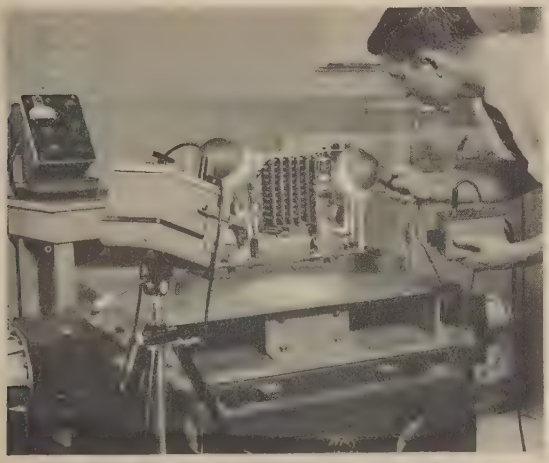


Figure 2-3. Vibration test, using a stroboscope and a Type 1539 Stroboslave.

2.11 USE IN HIGH-SPEED PHOTOGRAPHY.

The short duration of the light flash from a Type 1531 Strobotac, triggered by a controlled time-delay pulse from the Type 1531-P2 Flash Delay, allows the photographer to capture on the film the image of very fast moving objects (see Figure 2-4). The instrument can be triggered

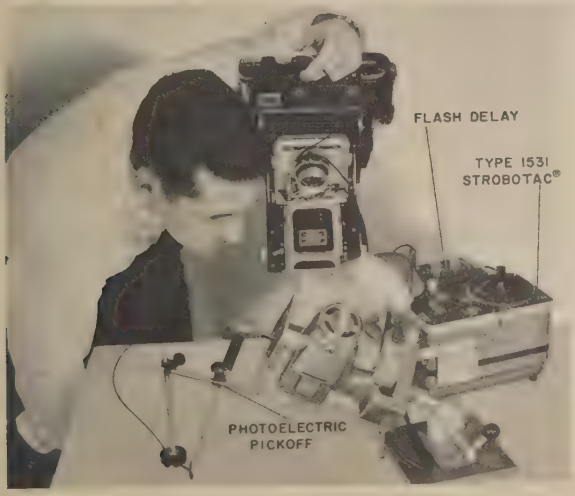


Figure 2-4. Stroboscope, Flash Delay, and Photoelectric Pickoff used for high-speed photography.

by an external signal (e.g., from a photocell or microphone) for synchronization of a single flash, or can be set to flash at a given rate for multiple exposures. The entire system should be checked for proper synchronization before the film is loaded into the camera.

Determining correct film exposure is simplified by the use of a guide number (GN) that relates the lamp-to-subject distance (d) to the camera-aperture setting (f):

$$f = \frac{GN}{d}$$

The guide number, as determined from Figure 2-5, is used for single-flash applications. When repetitive flashing of the stroboscope is required, the guide number must be multipled by a correction factor (Guide Number Multipler - K) taken from Figure 2-6.

It is necessary in computing aperture setting to modify the distance measured between the stroboscope and the subject. The light from the unit must be considered as coming from a point 1.5 feet behind the front

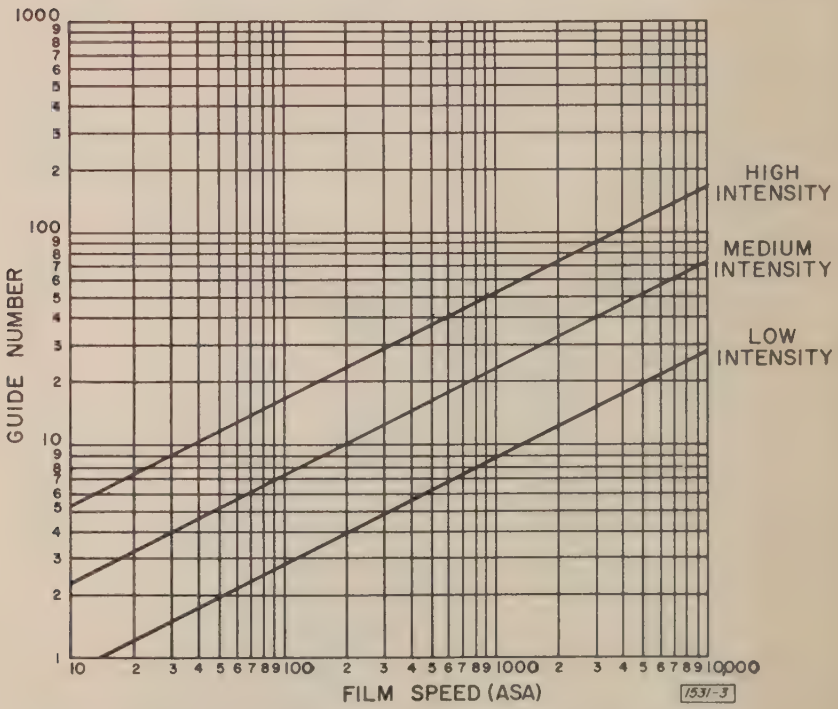

GUIDE NUMBER
1000
100
10
1
HIGH INTENSITY
MEDIUM INTENSITY
LOW INTENSITY
10 2 3 4 5 6 7 8 9 100 2 3 4 5 6 7 8 9 1000 2 3 4 5 6 7 8 9 10,000
FILM SPEED (ASA)
1531-3

Figure 2-5. Guide number versus film speed for Type 1531 intensity settings. Data for single-flash operation: see Figure 2-6 for correction required for repetitive flashing.

of the reflector. Therefore, 1.5 feet must be added to the measured distance between the stroboscope and subject. For example, if this distance is 2 feet, use 3.5 as the number to be divided into the guide number to obtain aperture setting.

The guide numbers shown in Figure 2-5 should be regarded as only a starting point for obtaining correct exposure. Contrast between subject

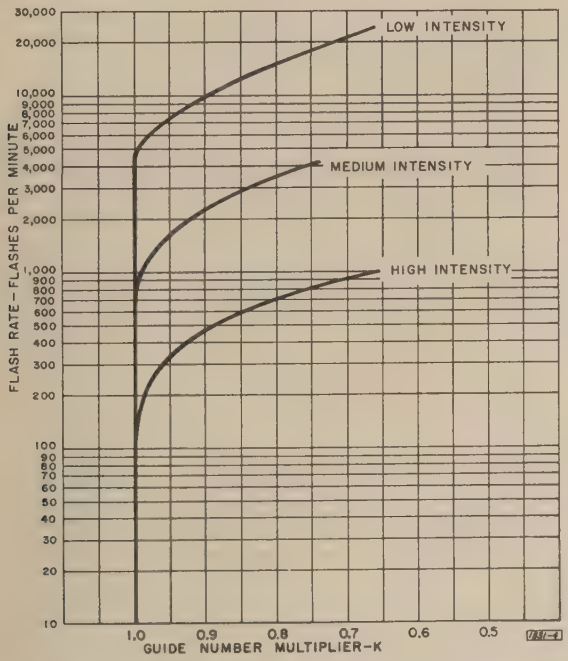


Figure 2-6. Guide number correction for repetitive flashing with a Type 1531 Stroboscope.

and background, type of film, development techniques, and many other variables should also be taken into consideration. Trial photographs are most helpful in determining optimum exposure. Follow the film manufacturer's recommendations when processing the film.

For detailed information on the use of the stroboscope for photographic applications, refer to General Radio's "Handbook of High-Speed Photography," available free on request.

SECTION 3

PRINCIPLES OF OPERATION

3.1 BASIC STROBOSCOPE OPERATION.

3.1.1 WHAT IS A STROBOSCOPE?

A stroboscope is a source of flashing light that can be synchronized with any fast, repetitive motion so that a rapidly moving device seems to stand still, or to move slowly.

To illustrate this principle, consider the following example:

Assume a white disc, with a single black dot, mounted on the shaft of an 1800-rpm motor.

When the disc is rotating at 1800 rpm, it is impossible for the human eye to distinguish a single image and the dot will appear to be a blurred continuous circle.

When illuminated by the flashing stroboscope light, synchronized to flash once every revolution of the disc (when the dot is at 3 o'clock, for example), the dot will be seen at this position – and only at this position – at a rate of 1800 times each minute. Thus, the dot will appear to "freeze" or stand still.

Now, if the flashing rate of the stroboscope is slowed to 1799 flashes per minute, the dot will be illuminated at a slightly different position each time the disc revolves, and the dot will appear to move slowly in the direction of rotation through 360° and arrive back at its original position (3 o'clock) one minute later.

A similar movement, but in a direction opposite the rotation of the dot, will be observed if the flashing rate of the stroboscope is increased to 1801 rpm. If desired, the rate of apparent movement can be speeded up by further increases or decreases in the stroboscope flashing rate.

1531-1

When the image is stopped, the flashing rate of the stroboscope equals the speed of the moving object and, since the flashing rate is known, the speed of the object is also known. Thus the stroboscope has a dual purpose of measuring speed and of apparently slowing down or stopping rapid motion for observation. The practical significance of the slow-motion effect is that, since it is a true copy of the high-speed motion, all irregularities (vibration, torsion, chattering, whip) present in the high-speed motion can be studied.

3.1.2 SINGLE AND MULTIPLE IMAGES.

Single images will occur at the fundamental speed of the object under observation, and at predictable submultiples of the fundamental speed. Multiple images will be observed at various speeds above and below the fundamental speed. Refer to paragraphs 2.8.1 and 2.8.2.

When the Type 1531 Strobotac is used for observation purposes only, the ability to distinguish between single and multiple images is usually not necessary. When making speed measurements, however, the operator must be able to make this distinction. Generally, odd-shaped (not symmetrical) objects cause little difficulty. Assume, for example, a fan with only one blade: the single blade will be seen when a single image occurs, two blades (180° apart) will be seen when a double image occurs, three blades (120° apart) will be seen when a triple image occurs, etc.

But when the object is symmetrical in shape (fan with 4 blades, for example), multiple images cannot always be distinguished from a single image. This difficulty is easily overcome; simply upset the symmetry of the object by applying a reference mark with pencil, paint, chalk, tape, etc. See Figure 3-1.

3.2 CIRCUIT DETAILS.

3.2.1 GENERAL.

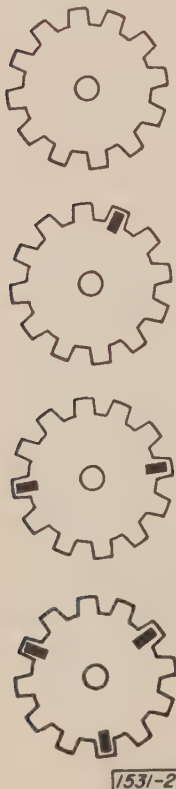
The Type 1531 Strobotac consists basically of a strobotron, an oscillator to determine the flashing rate of the strobotron, and a power

supply. Component designations in the following paragraphs refer to the schematic diagram, Figure 4-7.

3.2.2 STROBOTRON TUBE.

In most modern stroboscopes, the flash occurs inside a xenon-filled tube. The gas in the tube is ionized by the rapid discharge of a capacitor. The gas must then deionize before the next flash can occur. This deionization time sets the limit on the maximum flashing rate of the instrument. If too high a voltage is applied across the tube before it is deionized, an erratic condition (continuous conduction) known as "hold-over" will result.

The strobotron tube contains two main elements, a cathode and an anode. A discharge capacitor acts as a low impedance source of voltage across these electrodes. The gas, however, remains non-conducting (deionized) until a pulse of high voltage is applied to trigger wires inter-



Gear not marked for speed measurement. Simple observation is possible but observer cannot be certain if image is single or multiple.

Single image observed with tape applied to *one* tooth of gear.

Multiple (double) image observed with tape applied to *one* tooth of gear. Images are 180° apart.

Multiple (triple) image observed with tape applied to *one* tooth of gear. Images are 120° apart.

1531-2

Figure 3-1. Single and multiple images of a rotating gear as observed with a stroboscope.

spersed between the two electrodes. This trigger pulse ionizes the gas and causes current to flow through the tube, thus generating an intense flash of white light.

3.2.3 STROBOTRON CIRCUIT.

The high-voltage output from the trigger circuit is capacitively coupled from T2 to the strobotron. The coupling capacitors are built into the ceramic insulator in the swivel neck.

The energy to flash the strobotron is stored in the discharge capacitors C10, C11, and C14. The correct capacitance for each RPM range is connected across the strobotron by the range switch. After the strobotron flashes, the active capacitors are recharged to 800 volts dc. The unused capacitors are kept charged to 800 volts to reduce arcing at the switch contacts when the range-switch setting is changed.

3.2.4 OSCILLATOR.

The flashing rate of the instrument is controlled by an internal oscillator. The two sections of the oscillator tube (V1) constitute a bistable circuit; in such a circuit, one section conducts while the other section is shut off. Then, very rapidly, the two sections reverse states. Each section is alternately turned on and off at a rate determined by the values of resistors and capacitors in the circuit and the voltage setting of R3 (RPM control). Several of these components are adjustable by panel controls. The RPM control is R3; R1 and R5 are the calibration screwdriver adjustments. The range switch (S2) introduces the proper timing capacitor into the circuit to step the flashing rate up or down by a factor of 6.

3.2.5 TRIGGER CIRCUIT.

The output of the oscillator (V1) is applied to the thyratron tube (V2) through C8. The thyratron, together with C9 and the pulse transformer T2, is used to produce the high-voltage pulse necessary to trigger the strobotron.

3.2.6 POWER SUPPLY.

A voltage-doubler power supply furnishes +400 and -400 volts dc to operate the strobotron. The +400-volt supply is filtered by a two-stage R-C filter to obtain the +250 volt supply. The power transformer is capable of operating on line frequencies ranging from 50 to 400 c/s, and is normally wired for either 115- or 230-volt operation (see Figure 4-7).

3.2.7 EXTERNAL SYNCHRONIZATION.

For operating with an external synchronizing signal, the oscillator circuit is converted to a conventional, amplitude-sensitive, bistable circuit. The RPM control varies the bias on V1 so that optimum sensitivity for sine wave or pulse input signals can be obtained.

The greater the amplitude of the input signal, the greater will be the range of bias values that will allow proper flashing of the stroboscope.

The input circuit can also be driven by an external contactor. In such operation, half of the dc voltage divider, comprising R32 and R33, is short-circuited by the closing of the external contactor. The positive pulse required to operate the thyratron is generated by the input circuit, upon the opening of the external contactor switch. Thus the flashing is synchronized with the opening of the switch, not with the closing.

The input impedance at the panel input jack is about 500,000 ohms. Because of the dc voltage divider, about 50 volts dc is present at the input terminals.

Three frequency ranges for external input are provided: LOW INTENSITY, MED INTENSITY and HIGH INTENSITY. Operation above the maximum frequencies indicated will not damage the strobotron, but operation may become erratic. On the LOW INTENSITY range, the instrument can often be synchronized at frequencies up to 600 c/s (36,000 rpm) or higher, before the strobotron begins to misfire.

In LINE/EXT INPUT position, the Type 1531 Strobotac is synchronized with the power-line frequency, by means of an ac voltage from the power transformer applied to the input circuit. This voltage is removed from the circuit when a plug is inserted in the INPUT jack. Enough voltage is available to permit synchronization at all bias (RPM control) settings.

3.2.8 CALIBRATION CIRCUIT.

To calibrate the frequency dial against power-line frequency, voltages at both the power-line and the flashing-rate frequencies are superimposed across a neon bulb (V5).

When the flashing rate of the strobotron equals the power-line frequency, or a multiple or submultiple of it, the voltage across V5 will remain constant and the bulb will not vary in intensity. Depending upon the phase relation between the strobotron oscillator and the power-line voltage, the steady-state condition of the neon bulb may be maximum intensity, partial intensity, or zero intensity.

If the flashing rate of the strobotron differs from the power-line frequency, the voltage across the neon bulb will vary, and the intensity will change, at the difference frequency.

The above calibration can easily be made at many flashing rates between 600 and 7200 rpm. Below 600 rpm, the flashing rate will produce the appearance of flicker. The flicker frequency will be superimposed on the difference, or beat, frequency described above; when the flicker is pronounced, it may be difficult to distinquish between the flicker and the beat frequency. Above 7200 rpm, the variation in intensity may be so slight that calibration is difficult.

SECTION 4

SERVICE AND MAINTENANCE

4.1 WARRANTY.

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards, after examination by our factory, district office, or authorized repair agency personnel, will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

4.2 SERVICE.

The two-year warranty given with every General Radio instrument attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible.

In case of difficulties that cannot be eliminated by the use of these service instructions, please write or phone our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest district office (see back cover), requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification.

4.3 MAINTENANCE.

4.3.1 GENERAL.

The following paragraphs contain general maintenance information and brief instructions for replacing the fuse and the strobotron lamp.

4.3.2 CLEANING OF REFLECTOR AND COVER.

Since the inside of the reflector is well protected by the cover and by the seal at the swivel arm, it is improbable that impurities in the air will collect on the reflective surface. However, if it should become necessary to clean the inside of the reflector, first pull the reflector from the swivel assembly. Remove the cover by pushing on the edge of the cover at each of the three fingers that clamp over the reflector housing. Use a soft, lint-free cloth to clean the reflector surface and cover. If necessary, moisten the cloth with water. Do not use solvents of any kind, as they may mar the surface.

4.3.3 LOOSE FREQUENCY DIAL.

If the frequency (RPM) dial turns when the range-switch position is changed, the range-switch knob and mask are rubbing against the frequency dial. Remove the scale-mask assembly and reposition the frequency dial. Refer to paragraphs 4.6.3 and 4.6.4 for detailed instructions. When mounting the scale-mask assembly, be sure to maintain sufficient clearance between the mask and the dial. It is not necessary for the mask to project above the rim of the frequency dial to obtain adequate clearance.

4.3.4 CASE WILL NOT LOCK PROPERLY.

If the screws that fasten the side plates of the handle assembly to the cover become loose, proper operation of the slide pins may become difficult or impossible. Close the instrument and set the slide pins in the lock position by moving the side plates up or down. Tighten the screws on the side plate. Check operation in the open position. If necessary, loosen the side plate screws and reposition these plates slightly so the case will lock in both open and closed positions.

4.3.5 REPLACEMENT OF STROBOTRON LAMP.

To replace the strobotron lamp, remove the reflector from the swivel assembly by pulling it away from the panel of the instrument. Do not take off the reflector cover to replace the lamp. Make certain the replacement lamp is fully seated in the lamp socket.

WARNING

Avoid contacting the strobotron pins when removing the old lamp. When the instrument is turned on, 800 volts is present at the lamp pins. Also, the lamp may be quite hot (temperature) if the instrument has been turned on for a period of time.

4.3.6 REMOVAL OF INSTRUMENT FROM CASE.

To remove the instrument from the case, open the case and place the instrument with the panel in a vertical position. Make certain to unplug the power connector before starting the next step. Remove the four screws from the side of the case opposite the panel and pull the instrument forward. For access to the parts located on the panel, remove

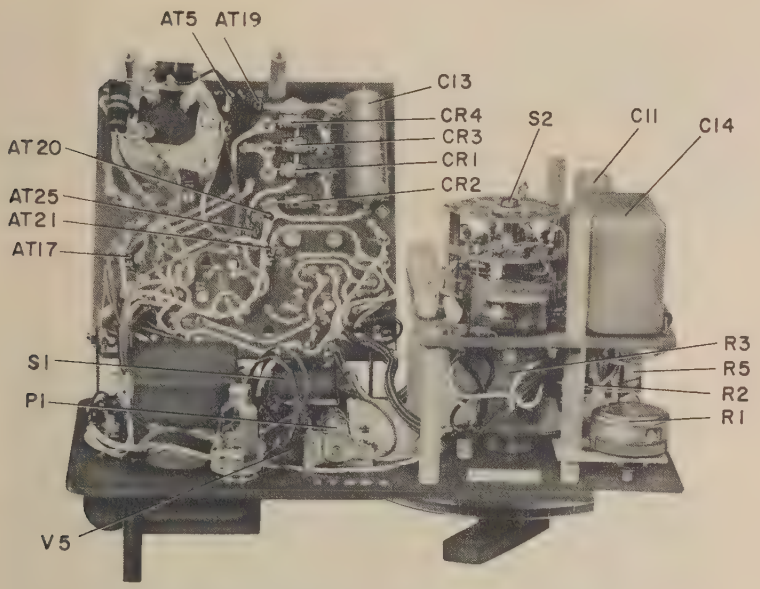


Figure 4-1. Side internal view of Type 1531 stroboscope with etched board swung open.

the screw directly under the INPUT jack, and pivot the etched board containing the power transformer away from the panel (see Figure 4-1). Avoid damage to parts, do not allow the etched board to swing free.

4.3.7 REPLACEMENT OF FUSE.

To replace the fuse, first remove the instrument from the case (refer to paragraph 4.3.6). The fuse is located near the front of the instrument on the etched board (see F1, Figure 4-2). Be sure to insert a proper-value fuse, as indicated in the parts list.

4.4 TROUBLE ANALYSIS.

4.4.1 GENERAL.

A General Radio Type 1806 Electronic Voltmeter, or any reliable voltohmeter, can be used for most checks described in the following paragraphs.

4.4.2 PRELIMINARY CHECKS.

If the stroboscope is inoperative, make the following simple checks before removing the instrument from its case:

a. Check that voltage is available at the power receptacle to which the unit is connected.

b. Check that the voltage and power-line frequency of the power source agree with the data on the panel of the instrument. If conversion for a different input voltage is required, refer to paragraph 4.4.3.

c. Check that the range switch is not in one of the EXT INPUT positions.

d. Turn the instrument off and turn it on again after 10 seconds. (The thyratron may hold over if the instrument is in an EXT INPUT position when a plug is inserted in the INPUT jack.)

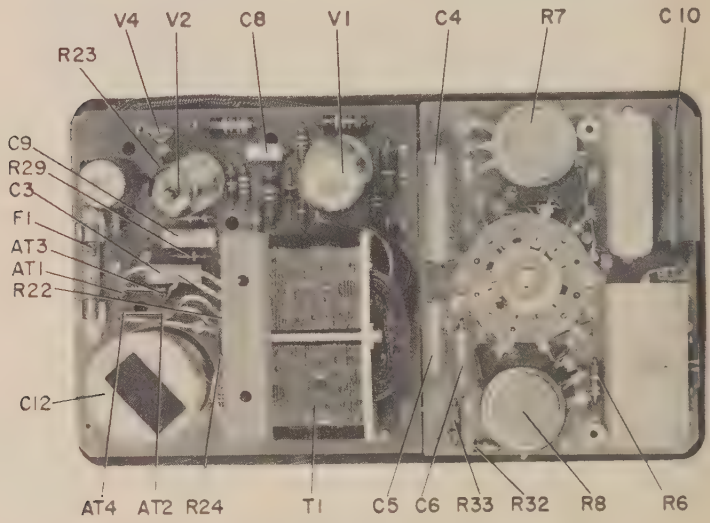


Figure 4-2. Top internal view of Type 1531 Strobotac.

4.4.3 CONVERSION FOR DIFFERENT INPUT VOLTAGE.

To convert from one line-voltage input to another, remove the jumpers which interconnect the transformer windings. These jumpers are located on the etched board. Connect the proper jumpers as noted on the schematic diagram (see Figure 4-7). Terminals AT1 and AT4 are those located nearest to the fuse. See Figure 4-2. The numbers are silk-screened on the reverse side of the board. Insert a proper-value fuse.

If the input voltage is changed, the plate on the panel, just above the power cord, should either be removed or marked to indicate the correct power input required. Recommendation: remount the plate with the reverse side up and print new input requirements with an indelible marking device.

4.4.4 NO FLASH – NO DIAL LIGHT.

If the strobotron tube will not flash and the RPM dial is not illuminated; unplug the instrument, remove it from the case, and:

a. Check for open fuse. If fuse blows when replaced, refer to paragraph 4.4.5.

b. Flip power switch on and check for continuity between pins of power-cord plug. If continuity check indicates an open circuit, check power switch and continuity of the power input circuit.

It is possible that the pilot lamp is defective and there is also some other difficulty preventing the strobotron from flashing. Refer to paragraphs 4.4.6 and 4.4.7.

4.4.5 INSTRUMENT BLOWS FUSES.

If the stroboscope continually blows fuses (see Figures 4-1, 4-2, and 4-7):

a. Make certain replacement fuse is correct value.

b. Make certain transformer is properly connected.

c. Check for accidental short circuits to ground at secondary of power transformer (AT5), or +400-volt (AT17) and -400-volt (AT20) lines.

d. Check for possible short circuits across C12C or C13.

e. Check for low back resistance of rectifier diodes CR1, CR2, CR3, and CR4. Measure forward and back resistance of each diode. (Measured values will depend upon type of instrument and scale used.) The back resistance should be much greater — 100 times greater, for example — than the forward resistance. (The +400- or -400-volt supply will probably be low if diodes are faulty).

4.4.6 NO DIAL ILLUMINATION.

If the indicator under the RPM dial is not illuminated, but the strobotron lamp fires, pilot lamp (P1, Figure 4-1) is defective. To replace, swing back the etched board (refer to paragraph 4.3.6) and unclip the lamp socket from its bracket. The lamp can now be easily replaced.

4.4.7 STROBOTRON DOES NOT FLASH.

If the strobotron lamp will not flash, but the pilot light is on:

a. Check that the range switch is not in one of the EXT INPUT positions.

b. Turn the instrument off and turn it on again after 10 seconds. The thyratron may hold over if the instrument is in an EXT INPUT position when a plug is inserted in the INPUT jack.

c. Make certain the strobotron is firmly seated in the lamp socket (refer to WARNING paragraph 4.3.5).

d. Check power-supply voltages (+250V, +400V, and -400V).

e. Replace V1 (5965) or V2 (5727).

4.4.8 STROBOTRON FLASHES ERRATICALLY.

If the strobotron lamp arcs at the base, the lamp is at the end of its useful life and should be replaced.

a. If the strobotron fires erratically when the stroboscope is triggered from an external contactor, the trouble may be due to contact bounce at the contactor contacts.

b. If the strobotron lamp flashes at the same rate, regardless of the RPM dial setting on all three speed ranges, potentiometer R3 (see Figure 4-1) is probably open-circuited.

c. If erratic firing continues, the trouble is probably due to hold over and the strobotron lamp should be replaced.

4.4.9 NO INDICATION FROM CALIBRATION LAMP.

If the stroboscope flashes, but the CAL indicator lamp remains out when the HIGH CAL and LOW CAL settings are adjusted (see Figures 4-1 and 4-2):

a. The CAL indicator neon lamp V5 may be defective. Remove the instrument from its case and then remove the two screws that secure the lamp holder to the instrument panel. Unsolder the lamp from the terminals and replace with a new lamp.

b. The neon lamp V4 may be defective. Unsolder the lamp from the etched board and replace with a new lamp.

c. Capacitor C3, or resistor R22, R23, R24, or R29 may be defective. Replace if necessary.

4.4.10 INSTRUMENT CANNOT BE CALIBRATED.*

If the stroboscope cannot be calibrated by following instructions given in Section 2, OPERATING PROCEDURE, see Figures 4-1 and 4-2, and check the following:

a. Tube V1 (5965) may be defective. Replace if necessary.

b. If the unit cannot be calibrated at either the 3600 RPM or 900 RPM positions, check rheostats R1 and R5, and resistors R2 and R6 for proper values.

c. Check that the RPM control has not become loose and moved with respect to the shaft of R3. If so, refer to paragraph 4.6.4.

d. Check capacitor C5 for proper value.

4.4.11 INCORRECT RATIO BETWEEN RANGES.*

If the 6:1 ratio between frequency ranges is not correct within 1%, see Figures 4-1 and 4-2, and proceed as follows:

a. Do not adjust individual frequency ranges without the use of a disk mounted on the shaft of a synchronous motor. The disk should be clearly marked with a large dot. Any 1500 rpm (50 cycle), or 1800 rpm (60 cycle) synchronous motor, in good working order, will be suitable The number of patterns that will appear on the disk at various frequency settings of the stroboscope is given in Table 4-1.

*In the following steps, calibration settings are those to be used with 60-cycle service; users of 50-cycle power should multiply these settings by 5/6.

Table 4-1

CALIBRATION WITH SYNCHRONOUS MOTOR AND ONE-SPOT DISK

RPM Dial			RPM Dial		
50-cycle 1500-rpm motor	*60-cycle 1800-rpm motor*	*No. of Spots Seen*	*50-cycle 1500-rpm motor*	*60-cycle 1800-rpm motor*	*No. of Spots Seen*
125	150	1	3000	3600	2
250	300	1	3750	4500	5
300	360	1	4500	5400	3
375	450	1	6000	7200	4
500	600	1	7500	9000	5
600	720	2	9000	10,800	6
750	900	1	10,500	12,600	7
900	1080	3	12,000	14,400	8
1000	1200	2	13,500	16,200	9
1125	1350	3	15,000	18,000	10
1200	1440	4	16,500	19,800	11
1250	1500	5	18,000	21,600	12
1500	1800	1	19,500	23,400	13
2000	2400	4	21,000	———	14

b. Remove the instrument from the case (refer to paragraph 4.3.6) so that potentiometer R7 and R8 are accessible. These potentiometers are located one on each side of the range switch on the etched board.

c. Allow the instrument to warm up for at least one hour.

d. Set the range switch to the 4000-25,000 RPM range and set the RPM control to 21,600 RPM. Adjust the HIGH CAL control on the panel to obtain a stationary pattern (12 images for an 1800-rpm motor).

e. Set the RPM dial to 5400 RPM and adjust the LOW CAL control on the panel to obtain a stationary pattern (three images for an 1800-rpm motor).

f. Repeat steps d and e until no further adjustment is necessary.

g. Set the range switch to the 670-4170 position and set the RPM dial to 3600 RPM.

h. Adjust potentiometer R7 so that a stationary pattern is obtained (two images for an 1800-rpm motor). Check operation at 900 RPM by adjusting the RPM control until the image is stationary (one image for an 1800-rpm motor). The correct setting should be less than one-half division from the 900 RPM mark. If the setting is not correct, repeat steps d, e, f, and check setting again.

i. Set the range switch to the 110-690 RPM position and set the RPM control to 600 RPM.

j. Adjust potentiometer R8 so that a single stationary image is obtained. Check operation at 150 rpm. The stationary-image setting

should be within one-quarter of a division of the 150 RPM mark. If not, repeat steps d, e, and f before checking this setting again.

k. If the above procedure does not correct the difficulty, try replacing tube V1 (5965), and check values of C4, C5, and C6.

4.5 TEST VOLTAGES.

Test voltages from tube pins to ground are shown on the schematic diagram, Figure 4-7. Voltages are dc unless otherwise indicated. Deviations of up to 20 percent from the stated dc voltage should not be considered abnormal. Voltage ranges given for V1 are to be measured with R3 (the RPM control) either fully clockwise or fully counter clockwise (refer to VOLTAGE MEASUREMENTS on schematic diagram).

4.6 REPLACEMENT OF MECHANICAL PARTS.

Although the stroboscope is designed for use in manufacturing, test, and other areas where the working environment is often unsuitable for precision electronic instruments, certain mechanical parts mounted on the outside of the instrument case may eventually become contaminated or damaged. To replace these parts (see Figure 4-3), refer to the following instructions.

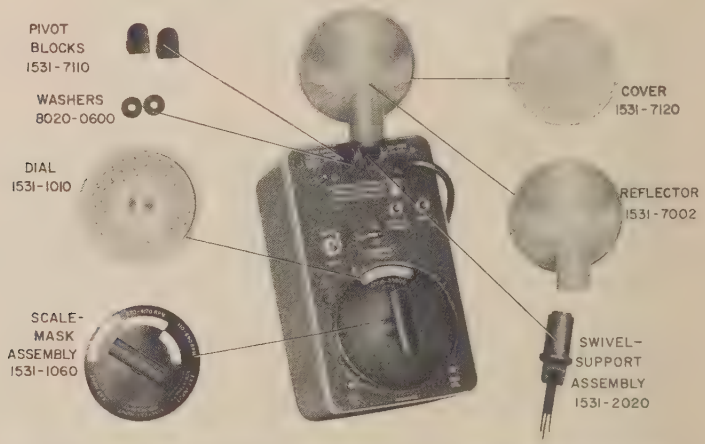


Figure 4-3. Location and part numbers of mechanical parts for the Type 1531 Strobotac.

4.6.1 REFLECTOR AND COVER.

Remove the old reflector by pulling it away from the swivel-support assembly. Mount the new reflector by sliding it onto the swivel-support assembly until the spring-loaded detent button snaps into the groove inside the reflector base.

To replace the reflector cover, remove the old cover by pushing on the edge at each of the three flanges that clamp over the rim of the reflector housing. Then, mount the new cover by pulling the edge of the cover toward the rim of the reflector housing until the three flanges snap securely in place.

4.6.2 SWIVEL-SUPPORT ASSEMBLY, PIVOT BLOCKS, AND WASHERS.

See Figure 4-4. To replace the swivel-support assembly:

a. Remove the reflector, the strobotron lamp, and then remove the instrument from its case.

b. Loosen (do not remove) two nuts (A) and slide the two pivot blocks apart. (The heads of the two screws (B) clamp the pivot blocks in position when nuts (A) are tightened.)

c. Unsolder the three swivel-support assembly leads (X, Y, Z) and remove the assembly.

NOTE

If desired, the pivot blocks and washers may now be replaced.

d. Position the new swivel-support assembly so that the strobotron tube socket and leads (X, Y, Z) can be mounted as shown in Figure 4-4.

e. Insert leads (X, Y, Z) through the slot between screws (B), and hold the swivel-support assembly in position between the two pivot

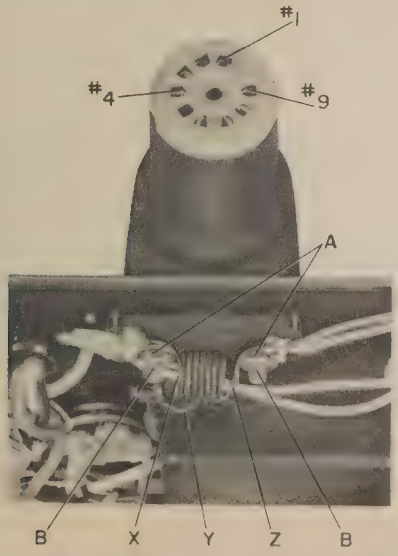


Figure 4-4. Internal view of Type 1531 Strobotac. Lead connection terminals and mounting of swivel-support assembly.

blocks. Slide the pivot blocks together and tighten nuts (A). The pivot action of the swivel-support assembly may need adjustment; if so, loosen one nut (A), adjust the corresponding pivot block, and tighten the nut again.

f. Solder leads (X, Y, Z) to terminals (see Figure 4-4).

4.6.3 SCALE-MASK ASSEMBLY.

To replace the scale-mask assembly:

a. Set the range switch to the 4000-25,000 RPM position.

b. Loosen the two setscrews in the scale-mask assembly hub and remove the assembly from the range-switch shaft.

c. Mount the new scale-mask assembly on the shaft and center the 4000-25000 RPM window in the dial over the white panel segment beneath the dial.

d. Tighten both setscrews securely.

4.6.4 DIAL.

To replace the dial:

a. Remove the instrument from the case.

b. Set the range switch to the 4000-25000 RPM position and remove the scale-mask assembly (refer to paragraph 4.6.3, steps a and b).

c. Note the approximate dial setting and remove the dial from the potentiometer shaft without turning the shaft. To remove the dial, loosen the two setscrews in the dial hub under the instrument panel.

d. Mount the new dial at the approximate setting noted in step c. Tighten one setscrew in the dial hub.

CAUTION

The dial should not rub against the panel when rotated; allow for a minimum clearance of 1/16 inch.

e. Rotate the dial from the limit stop in one direction to the limit stop in the other direction. Note the distance between the red marker and both ends of the 4000-25000 RPM scale. (The ends of the scale should travel approximately 1/4 inch beyond the red marker.) Adjust the dial until the red marker is *equidistant* from both ends of the scale.

f. Tighten both setscrews in the dial hub.

g. Mount the scale-mask assembly (paragraph 4.6.3, steps c and d,) and mount the instrument in the case.

h. Calibrate the stroboscope before making speed measurements.

Figure 4-5a. Etched-board layout of Type 1531 Oscillator-Trigger circuit and switch circuit.

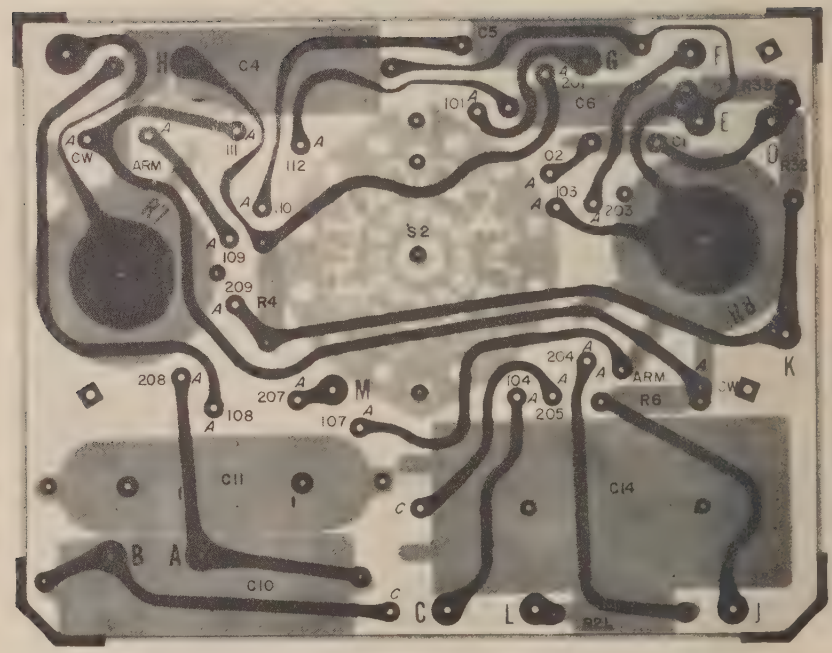


Figure 4-5b. Etched-board layout of Type 1531 Switch Circuit (part number for complete assembly: 1531-2710).

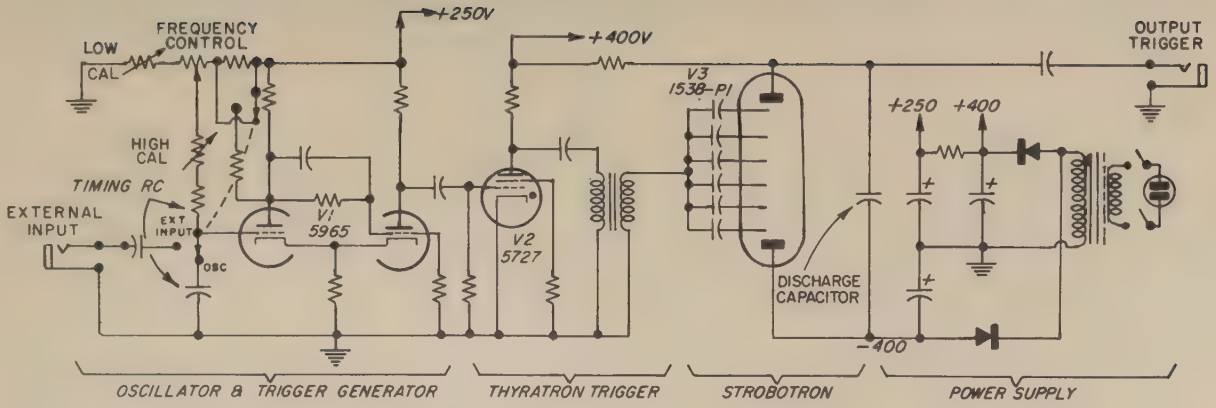


Figure 4-6.
Elementary schematic diagram for Type 1531 Strobotac.

PARTS LIST

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C1	Ceramic, 0.01 μF ±20 % 500 V	4406-3109
C3	Plastic, 0.0047 μF ±10% 600 V	4860-7400
C4	Plastic, 0.182 μF ±1% 400 V	4860-7900
C5	Plastic, 0.030 μF ±1% 400 V	4860-7600
C6	Plastic, 0.00523 μF ±1% 400 V	4860-7500
C7	Ceramic, 10 μF ±10% 500 V	4400-1100
C8	Ceramic, 100 μF ±10% 500 V	4400-4600
C9	Plastic, 0.0047 μF ±10% 600 V	4860-7400
C10	Viscofilm, 0.047 μF ±10% 1000 V	1531-4000
C11	Viscofilm, 0.22 μF ±10% 1000 V	1531-4010
C12A	Electrolytic, 50 μF 450 V	4450-0800
C12B	Electrolytic, 25 μF 450 V	4450-0800
C12C	Electrolytic, 25 μF 450 V	4450-0800
C13	Electrolytic, 4 μF 475 V	4450-2000
C14	Viscofilm, 1.15 μF 10 % 1000 V	1531-4020
C15	Ceramic, 0.01 μF +80-20% 2000 V	4428-3109
C16	Ceramic, 0.0047 μF ±10% 500 V	4407-2478
	RESISTORS	
R1	Potentiometer, composition 5 kΩ ±10%	6010-0800
R2	Composition, 13 kΩ ±5% 1 W	6110-3135
R3	Potentiometer, composition 50 kΩ ±2%	0975-4030
R4	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R5	Potentiometer, composition 2.5 mΩ ±20%	6010-2450
R6	Composition, 3.3 mΩ ±5% 1/2 W	6100-5335
R7	Potentiometer, composition 500 kΩ ±10%	6010-2200
R8	Potentiometer, composition 500 kΩ ±10%	6010-2200
R9	Composition, 15 kΩ ±5% 1 W	6110-3155
R10	Composition, 240 kΩ ±5% 1/2 W	6100-4245
R11	Composition, 1.1 mΩ ±5% 1/2 W	6100-5115
R12	Composition, 10 kΩ ±5% 1 W	6110-3105
R13	Composition, 8.2 kΩ ±5% 1 W	6110-2825
R14	Composition, 240 kΩ ±5% 1/2 W	6100-4245
R15	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R16	Composition, 510 kΩ ±5% 1/2 W	6100-4515
R17	Composition, 24 kΩ ±5% 1/2 W	6100-3245
R18	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R19	Composition, 100 kΩ ±10% 2 W	6120-4109
R20	Ceramic, 30 kΩ ±10% 25 W	1531-0410
R21	Composition, 82 kΩ ±10% 1 W	6110-3829
R22	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R23	Composition, 150 kΩ ±5% 1/2 W	6100-4155
R24	Composition, 560 kΩ ±5% 1/2 W	6100-4565
R25	Composition, 51 Ω ±5% 2 W	6120-0515
R26	Composition, 6.8 kΩ ±5% 1 W	6110-2685
R27	Wire-wound, 2.7 Ω ±10% 1/2 W	6760-9279
R28	Composition, 10 kΩ ±5% 2 W	6120-3105
R29	Composition, 150 kΩ ±5% 1/2 W	6100-4155
R31	Wire-wound, 6.8 Ω ±10% 1/2 W	6760-9689
R32	Composition 1 mΩ ±5% 1/2 W	6100-5105
R33	Composition, 1 mΩ ±5% 1/2 W	6100-5105
R34	Composition, 3.3 mΩ ±5% 1/4 W	6099-5335
R35*	Composition, 100 Ω ±5% 1/2 W	6100-1105

*Part of T2.

PARTS LIST (Cont)

REF NO	DESCRIPTION	PART NO
	MISCELLANEOUS	
L1	Choke, 680 µH ±10%	4300-4600
CR1	Diode, Type 1N3254	6081-1002
CR2	Diode, Type 1N3254	6081-1002
CR3	Diode, Type 1N3254	6081-1002
CR4	Diode, Type 1N3254	6081-1002
CR5*	Diode, Type 1N3254	6081-1002
F1	Fuse, 115 V, 0.5 A	5330-1000
	230 V, 0.25 A	5330-0700
J1	Jack	1531-0490
J2	Jack	4260-1260
P1	Pilot light, Type 2 LAP-939, 6.3 V	5600-0700
S1	Switch, Toggle, DPST	7910-8353
S2	Switch, Rotary wafer	7890-1830
T1	Transformer	0345-4760
T2	Transformer	1531-2000
V1	Tube, Type 5965	8380-5965
V2	Tube, Type 5727	8380-5727
V3	Tube, Strobotron, Type 1538-P1	1538-9601
V4	Tube, Type NE-2H	8390-0300
V5	Tube, Type NE-2H	8390-0300

*Part of T2.

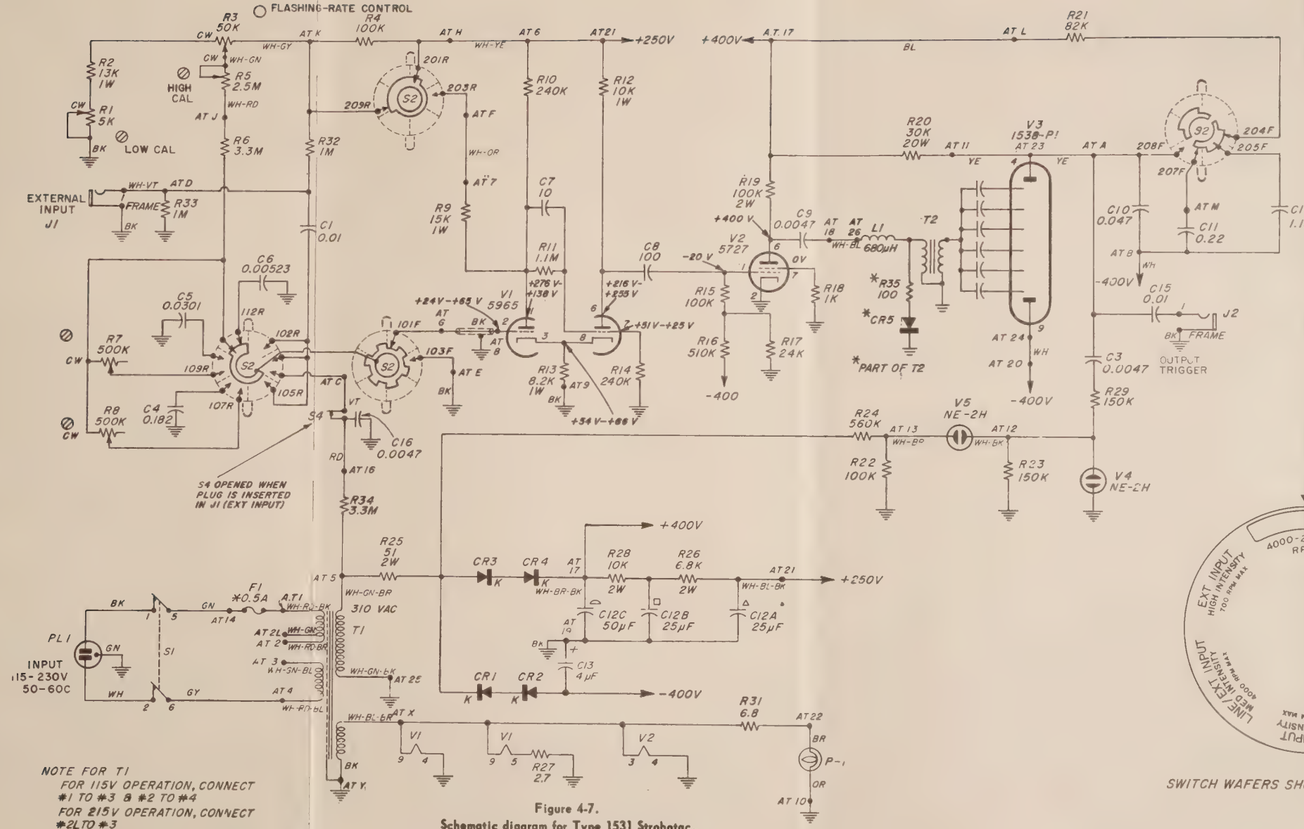


Figure 4-7.
Schematic diagram for Type 1531 Strobotac.

NOTE FOR T1
FOR 115V OPERATION, CONNECT #1 TO #3 & #2 TO #4
FOR 215V OPERATION, CONNECT #2L TO #3
FOR 230V OPERATION CONNECT #2 TO #3

* F1, 215V OR 230V 0.25A

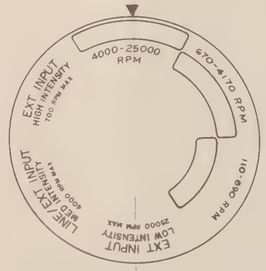
NOTES:
RESISTORS 1/2 WATT UNLESS OTHERWISE SPECIFIED
RESISTANCE IN OHMS UNLESS OTHERWISE SPECIFIED K=1000 OHMS M=1 MEGOHM
CAPACITANCE VALUES ONE AND OVER IN MICRO MICROFARADS, LESS THAN ONE IN MICROFARADS, UNLESS OTHERWISE SPECIFIED
○ PANEL CONTROL
⊘ SCREWDRIVER CONTROL

ROTARY SWITCH TERMINAL NUMBERING
2 01 F
FRONT OR REAR
CLOCKWISE FROM STRUT VIEWED FROM KNOB
WAFER NUMBERED FROM KNOB END

A.T.'S USED: A,B,C,D,E,F,G,H,J,K,L,M, X,Y
1,2,2L,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26

VOLTAGE MEASUREMENTS

Measured with 20,000 ohms/volt meter
Unit operating on 115 volt line
Range switch on EXT INPUT, HIGH INTENSITY
Where a voltage range is given, first voltage is with R3 (flashing rate control) fully clockwise, second voltage with R3 fully counter-clockwise.
Voltages may deviate 20%



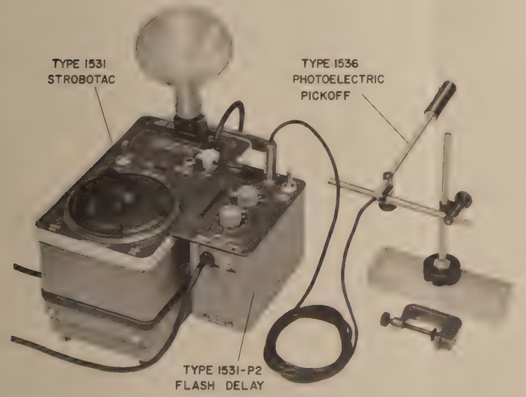
SWITCH WAFERS SHOWN IN THIS POSITION

APPENDIX

Type 1531-P2 FLASH DELAY

The Type 1531-P2 Flash Delay provides a continuously adjustable time-delay between an external triggering device and a stroboscope. The triggering device can be an oscillator, photocell or other type of transducer.

A typical combination of flash delay, photoelectric pickoff and stroboscope (shown below) can be used for visual observation and analysis of repetitive motion whose period is not constant. The flash delay also provides means for precise synchronization of camera shutter, stroboscopic flash, and objects moving at irregular speeds for high-speed photography.



SPECIFICATIONS

Time-Delay Range: Approximately 100 μs to 0.8 s in three ranges.
Output Pulse: Better than 13 V available for triggering the Types 1531-A and 1538-A Strobotac® electronic stroboscopes and the Type 1539-A Stroboslave.
Sensitivity: As little as 0.3-V input will produce sufficient output to trigger the stroboscope.
Inputs: Phone jack for triggering; jack for camera synchronization.
Accessories Available: Type 1536-A Photoelectric Pickoff.
Power Required: 105 to 125 or 210 to 250 V, 50 to 400 c/s, 5 W with Type 1536-A connected.
Mounting: Aluminum case with bracket, which clips directly onto the Strobotac electronic stroboscope.

Type 1536-A PHOTOELECTRIC PICKOFF

The Type 1536 Photoelectric Pickoff contains a light source, an optical system, and a photocell which produces a pulse when light from a moving object is reflected back to the photocell. This output pulse is fed through a Type 1531-P2 Flash Delay, and then used to trigger a stroboscope. With this combination of instruments, the motion of objects rotating at irregular speeds can be analyzed visually or by photographic means.

SPECIFICATIONS

Maximum Pulse Rate: Approximately 2500 pulses/s as limited by the 200-μs time constant of the photocell and cable combination.
Power Required: 20 to 28 V dc, 40 mA. Power is supplied by the Type 1531-P2 Flash Delay or the Type 1150-B (or Type 1151-A) Digital Frequency Meter.
Accessories Supplied: 10-ft roll of ⅜-in black tape; 10-ft roll of ⅜-in silver tape; carrying case.
Mounting: C-clamp (capacity 1⅝ in, flat or round) or 1½-in magnet, both supplied.

Type 1537-A PHOTOELECTRIC PICKOFF

In appearance, the Type 1537 Photoelectric Pickoff is similar to the Type 1536. The Type 1537, however, has no light source; the photosensitive element is a silicon light-activate switch. The output from this transducer will trigger directly the Type 1538 Strobotac or the Type 1539 Stroboslave but cannot be used with the Type 1531.

SPECIFICATIONS

Operating Rate: Greater than 2500 pulses/s.
Power Required: 3 to 25 V dc; 0 to 100 μA depending on operating rate. Power is supplied by instrument with which it is used.
Accessories Supplied: 10-ft roll of ⅜-in black tape, 10-ft roll of ⅜-in silver tape, carrying case.
Mounting: C-clamp (capacity 1⅝ in, flat or round) or 1½-in magnet, both supplied.

Type 1539-A STROBOSLAVE

The Type 1539 Stroboslave is an inexpensive, auxiliary light source that will produce a flashing light with output characteristics that are similar to the Type 1531 Strobotac. This compact stroboscope will flash on command when triggered from a contact closure in a textile machine, printing press, etc., or from a variety of General Radio stroboscope equipment including the Type 1531 or the Type 1538 Strobotacs.

SPECIFICATIONS

Flashing-Rate Ranges: 0 to 700, 0 to 4200, 0 to 25,000 flashes per min on high-, medium-, and low-intensity ranges, respectively.
Flash Duration: Approx 0.8, 1.2, and 3 μs, measured at ½ peak intensity, for the low-, medium-, and high-intensity ranges, respectively.
Peak Light Intensity: Typically 0.6, 3.5, and 11 million beam candles (0.6, 3.5, and 11 × 10^6 lux measured at 1-m distance at the beam center), for low-, medium-, and high-intensity ranges, respectively. For single flash, 18 million beam candles at 1 meter.
Reflector Beam Angle: 10° at half-intensity points.
External Triggering: Either a switch closure across the input jack terminals or a 2-V (peak) positive pulse.
Power Required: 100 to 125 or 195 to 250 V, 50 to 400 c/s, 16 W
Accessories Supplied: Phone plug for input, mounting bracket.
Accessories Available: Type 1537-A Photoelectric Pickoff, Type 1531-P2 Flash Delay (with a Type 1536-A Photoelectric Pickoff), Type 1535-B Contactor.

Type 1531-P3 SURFACE-SPEED WHEEL

The Type 1531-P3 consists or two black nylon wheels mounted on the ends of a sectioned steel rod. When one of the wheels is held against a moving belt, pulley, roller, etc., the rotating wheel can be observed with a stroboscope and the linear surface speed of the object can be accurately determined.

SPECIFICATIONS

Speed Range: 10 to 2500 ft/min with small wheel and 50 to 12,500 ft/min with large wheel.
Dimensions: Wheels are 0.764 and 1.910 in dia, respectively. Three-section shaft totals 20 in in length.

Type 1538-A STROBOTAC®

The Type 1538 Strobotac is functionally similar to the type 1531, but the instrument has additional features which include:

Fourth flashing-rate range for higher speeds
Greater light intensity
6-foot extension lamp
Battery pack (rechargeable) plus conventional power-line operation.

Either instrument can be used to trigger the other when a second flashing-light source is required.

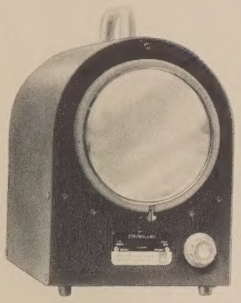
SPECIFICATIONS

Flashing-Rate Range: 110 to 150,000 flashes per minute in four direct-reading ranges: 110 to 690, 670 to 4170, 4000 to 25,000, and 24,000 to 150,000 rpm. Speeds to over 1 million rpm can be measured.
Accuracy: ±1% of reading on all ranges after calibration against line frequency.
Flash Duration: Approximately 0.5, 0.8, 1.2, and 3 μs for high-to-low speed ranges, respectively, measured at ½ peak intensity for single flashes with Type 1538-P4 High-Intensity-Flash Capacitor, 8 μs.
Peak Light Intensity: Typically 0.16, 1, 5, and 15 million beam candles (0.16, 1, 5, and 15 × 10^6 lux measured at 1 meter distance at the beam center) for high-to-low speed ranges, respectively; 44 million beam candles for single flash, with Type 1538-P4 High-Intensity-Flash Capacitor.
Reflector Beam Angle: 10° at half intensity points.
Output Trigger: Greater than 6-V positive pulse behind 400 Ω.
External Triggering: Either a switch closure across the input jack terminals, a 1-V, peak, positive pulse, or a 0.35-V, rms, sine wave down to 100 Hz increasing to 3.5 V, rms, at 5 Hz.
Power Required: 100 to 125 or 195 to 250 V, 50 to 400 Hz, 15 W or 20 to 30 V dc, 12 W.
Accessories Supplied: Adjustable neck strap, phone plug for input and output jacks, spare fuses.
Accessories Available: Type 1538-P2 Extension Lamp, Type 1538-P3 Battery and Charger, Type 1538-P4 High-Intensity-Flash Capacitor, Type 1531-P2 Flash Delay, Types 1536-A Photoelectric Pickoff (for use with Flash Delay), Type 1537-A Photoelectric Pickoff, and Type 1539-A Stroboslave.
Mounting: Flip-Tilt Case.
Dimensions: Width 10⅝*, height 6⅝, depth 6⅛ inches (270 by 170 by 160 mm), over-all.
Net Weight: 7¼ lb (3.3 kg).
Shipping Weight: 10 lb (4.6 kg).

* Includes handle.

Type 1532-D STROBOLUME

Useful as a light source for most low-speed stroboscope applications, the Type 1532 Strobolume produces a particularly brilliant flash of white light with a wide beam angle. The instrument can be triggered by a toggle switch or a push button for intermittent operation, or triggered for continuous flashing by an external contactor (General Radio Type 1535, for example) or the Type 1531 Strobotac.



SPECIFICATIONS

Flashing Speed Range:

High Intensity: Up to 60 flashes per minute continuous, up to 1200 per minute intermittent.

Low Intensity: Up to 3000 flashes per minute continuous.

Flash Duration: Approximately 30 μs at high intensity, 10 μs at low intensity.

Beam Width: 45° at half-intensity points.

Guide Number: The guide number (distance in feet times aperture) for high intensity is approximately 25 with film speed of 100 (ASA).

Flashing Control: TYPE 1535-B Contactor, or TYPE 1531-A STROBOTAC electronic stroboscope with TYPE 1532-P3 Trigger Cable.

Accessories Supplied: TYPE CAP-22 Power Cord, Contactor Cable Assembly, and plug for connection to contactor.

Accessories Required: None if lamp is to be flashed manually by pushbutton. For stroboscopic work a TYPE 1535-B Contactor, or a TYPE 1531-A STROBOTAC electronic stroboscope with TYPE 1532-P3 Trigger Cable, is needed. For use with older TYPE 631-BL STROBOTAC, a TYPE 1532-P2B Transformer Cable is required.

Cabinet: Metal case. Lamp assembly is removable. Storage space for lamp cable is provided in case. Lamp housing has ¼-20 threaded socket for tripod.

Power Required: 105 to 125 V, 50 to 60 c/s; 230-V model, TYPE 1532-DQ18, is available. Power consumption on high intensity is 105 W at 60 flashes per minute, 500 W at 1200 flashes per minute; at low intensity, 120 W at 3000 flashes per minute.

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